of other tree-grown mounds very similar in appearance to the one just excavated. Dr. Fewkes hopes next year to find what is concealed beneath.

UNIVERSITY AND EDUCATIONAL NEWS

THE contest over the will of the late General Brayton Ives, who left the bulk of his estate, valued at more than $1,000,000, to Yale University, has been settled by the filing of an order in surrogate's court. The contest was begun by General Ives's three daughters. The terms of the settlement were not divulged.

THE Duhring Memorial Building was formally dedicated on December 13 by the trustees of the University of Pennsylvania, and a memorial tablet was unveiled at the entrance to the new book stack. This new building is a wing to the library, and was erected as a memorial to the late Louis A. Duhring, professor of dermatology at the University of Pennsylvania, who left a legacy amounting to more than a million dollars to the university. The dedicatory addresses were made by Professor Morris Jastrow, Jr., the university librarian, and Dr. Joseph G. Rosengarten, chairman of the library committee of the board of trustees. The building was accepted on behalf of the university by Provost Edgar F. Smith.

A NEW building known as the Vivarium will soon be completed at the University of Illinois. It has been constructed especially for the work of Dr. Charles Zeleny and Dr. V. E. Shelford, of the department of zoology. The building, with furnishings, will cost about $70,000. Seawater aquariums, a refrigerator system, and rooms in which light rays may be used to the exclusion of all others, are some of the things which make up the equipment of the Vivarium.

ASSOCIATE PROFESSOR H. P. BARSS has been promoted to be professor of botany and plant pathology at the Oregon Agricultural College, in place of Professor H. S. Jackson, who recently resigned to accept the position of plant pathologist at Purdue University.

DR. ALBION WALTER HEWLETT, professor of medicine at the University of Michigan, has accepted a similar appointment, beginning on August 1, 1916, in the Medical School of Stanford University. This fills the vacancy left by the appointment of Dr. Ray Lyman Wilbur as president of the university.

ASSISTANT PROFESSOR A. L. LOVETT has been made acting head of the department of entomology at the Oregon Agricultural College, in place of Professor H. F. Wilson, who resigned to accept a position as professor of entomology at the University of Wisconsin.

COUNT HUTTEN-CZAPSKI, of Posen, has been appointed curator of the Warsaw University and Technical School, as reestablished under German auspices.

DISCUSSION AND CORRESPONDENCE

THE TEACHING OF ELEMENTARY DYNAMICS

TO THE EDITOR OF SCIENCE: Since I took a hand, in SCIENCE of March 29, 1915, in the controversy between Professors Huntington and Hopkins concerning the fundamental equation of dynamics, there have appeared numerous communications on the subject showing evidence of widespread interest in it. As a result of these communications, the questions at issue are now in a more chaotic state than they ever were. The time now seems opportune for a review of the positions held by the several contributors, in the hope that they may yet be brought into agreement. I offer here some brief extracts from letters that have appeared in SCIENCE in the last six months, with my comments upon them, together with a condensed restatement of the problem I gave, with my solution of it, in my previous article, again asking that if any one thinks he has a better solution he will present it for comparison.

Uniformly Accelerated Motion

Problem.—A constant force, F pounds, acts for T seconds on W pounds of matter, at rest at the beginning of the time but free to move. What are the results? Explain how the results are derived.

Answer.—Experiments with the Atwood machine and other apparatus show (a) that the velocity varies directly as the force and as the time, and inversely as the quantity of matter;

(b) that the distance or space traversed varies as the force, as the square of the time, and inversely as the quantity of matter. It equals half the product of the velocity and the time. Expressed in algebraic form:

Velocity, feet per second,

$$V = \frac{FTg}{W}. \tag{1}$$

Distance, feet,

$$S = \frac{1}{2}\frac{FT^2g}{W}, \tag{2}$$

$$S = \frac{VT}{2}. \tag{3}$$

The value of g in these equations is always 32.1740 when W is the quantity of matter in pounds, as determined by weighing it on an even balance scale, F is in standard pounds of force (1 pound of force being the force with which a pound of matter is attracted to the earth at the standard locality, a place where the "acceleration due to gravity" is 32.1740 feet per second per second), and V is measured in feet per second. (In the metric system, if F and W are in grammes and V in centimeters per second, $g = 980.665$.)

Transposing (1),

$$FT = \frac{WV}{g};$$

or if

$$M = \frac{W}{g}, \quad FT = MV. \tag{4}$$

From (3),

Impulse = Momentum.

$$T = 2S/V;$$

substituting this value of T in (4)

$$2\ FS/V = MV;$$

whence

$$FS = \tfrac{1}{2}\ MV^2. \tag{5}$$

In (4) let

Work done = Kinetic energy.

$$V/T = A,$$

acceleration, then

$$A = M/F.$$

Whence

$$F = MA.$$

Force = M times acceleration.

Falling Bodies.—At or near 45 deg. latitude at the sea level $F = W$, then from (1) we have $V = gT$. If $T = 1$ second $V = 32.1740$ feet per second. At other locations, $F = W \times (g_1/g)$, or $Wg/32.1740$, where g_1 is the acceleration due to gravity at the given location. In equation (1) $V = FTg/W$, taking $F = W$, substituting for T its value $2S/V$, and for S the letter H, for height of fall, we obtain

$$V^2 = 2\ gH; \quad V = \sqrt{2\ gH}. \tag{7}$$

The expression Wg_1/g may be called the "local weight." It equals the gravitational attraction, measured in standard pounds of force, upon W pounds of matter. It is the weight that is indicated on a spring balance calibrated for the standard locality, so that it will measure standard pounds of matter at 45° at the sea level and standard pounds of force at any locality whatever.

Professor Hoskins, April 23:

> . . . introduce at the outset the body-constant which was called by Newton *mass* or *quantity of matter* . . . the acceleration of a body depends quantitatively upon both the applied force and the mass of the body . . . and the still more concise form $A = F/m$ results if units are so chosen that *unit force acting upon unit mass causes unit acceleration.*

There is no objection to these statements if it is clearly understood what is meant by the terms unit force and unit mass, but Professor Hoskins might have gone further and shown that this form of equation results if F is in dynes and m in grams or if F is in poundals and m in pounds, or if F is in pounds and m in slugs, but that is *not true* if F and m are both in pounds. It is true, however, if it is understood that F is standard pounds of force and that m is merely a symbol for the ratio W pounds of matter divided by 32.1740.

> Standard weight defined as the force required to give the body the acceleration 32.1740 ft. per sec. It is important to make clear the fact that the quantity called standard weight is in reality the measure of a body constant and is quite independent of gravity in spite of the fact that it is given a name which is almost always associated with gravity.

Professor Hoskins and I are here in exact agreement, but I am not sure that he is aware

of it. I hold that the standard weight of a body is the number of pounds of force required to give the body the acceleration 32.1740 ft. per second, whether that is the earth's gravitational attraction on the body at the standard locality or whether it is the force required to slide it along a frictionless plane with the same acceleration. It is also the measure of a "body-constant," viz., the constant quantity of matter in the body, as determined by weighing it on an even balance scale, which is quite independent of the value of the force of gravitation at the place where the weighing is done. The quantity of matter might also be determined by multiplying its volume by its specific gravity, or, if its specific heat were known, by finding how many degrees it would heat a given volume of water. For example, a piece of iron in cooling 100 deg. F. heats a cubic foot of water 1 deg., what is its weight, the specific heat of the iron being 0.111, and 62.36 British thermal units being required to heat a cubic foot of water one degree? Answer, $62.36 \div (100 \times 0.111) = 5.62$ lbs.

In other words, weight, or standard weight, is both a quantity of matter and a force. While matter and force are two entirely different things, force being a push or a pull and matter something that may be pushed or pulled, the quantity of matter in a body may be determined by finding how much force is required to lift it. Both the quantity of the matter and the amount of force are called the weight of the body. They are different things, but numerically they are the same. The weight of a 1 lb. weight (piece of metal) is one pound, that is there is a pound of matter in it, and the force required to lift it is also called its weight and is a pound, of force (not a pound-weight, with or without the hyphen, for that is a term that is properly applied to a piece of metal used for weighing other bodies).

This double definition of the word weight is sanctioned by a thousand years of usage. It is universal in literature and in commerce. In the vain attempt to get rid of it the textbook writers have substituted the word "mass" for weight, meaning quantity of matter, and tried to confine the word weight to mean the amount of gravitational force acting on a body; but the great public will not have it so; they will continue to call both the force and the quantity of matter by the good old word weight. Then the text-book writers thought it would be a good thing to hybridize the C.G.S. system with the English system of weights and measures, and say unit force is that force which gives unit mass unit acceleration, and they invented the poundal to achieve this result; then, that device leading to trouble and confusion, they invented the gee-pound or slug and so increased the trouble.

In fact it (a supported body) has an acceleration even though at rest relatively to the earth.

I do not understand Professor Hoskins here. If acceleration means change of velocity divided by time, and rest connotes no change of velocity and no velocity, how can a body at rest on the earth's surface have an acceleration relatively to the earth, that is radially toward the earth's center, or relatively to a fixed point in space, if there is no change in the speed of rotation of the earth?

Professor Hoskins, May 7:

Mr. Kent's equation $V = KFT/W$ is entirely satisfactory and sufficient so long as our study is confined to the cause in which a force whose direction and magnitude remain constant acts upon a body otherwise free and initially at rest. This is, however, a very exceptional case. The fundamental principle in its generality can be expressed only by introducing the notion of instantaneous rate change of velocity, *i. e.*, acceleration.

I am glad that Professor Hoskins admits the sufficiency of the equation for the particular case to which I applied it, that of the body initially at rest acted on by a force constant in magnitude and direction. I call this equation fundamental because it is derived from experiment with the Atwood machine or other apparatus, and because it is a foundation upon which other equations may be built. Now let us build on it to arrive at the general case, by removing the restrictions of the original problem. Take unit force as the force which acting for one second gives a pound of matter a velocity of 32.1740 feet per second, then the

equation becomes $V = 32.1740\ FT/W$. Remove the restriction that the body starts from rest, and let it have at a given instant a velocity V_1 and at the end of the time T a velocity V_2. Let $V = V_2 - V_1$, then the equation applies equally well to this case, if we define V as the *increase* of velocity during T seconds.

Now remove the restrictions that the body is not retarded by friction and that the force is constant. The velocity then will not vary directly as the time, but in some other way, which can be expressed graphically by plotting velocities or distances against time. The problem is now not one of uniformly accelerated motion and it belongs to another chapter of the discussion, but we can still use the same formula if we differentiate it, assuming that for a differential of the time the force and the quantity of matter are constant. We then have $dv = 32.1740\ F/W\ dt$ or $dv/dt = 32.1740\ F/W$. This is a formula for the general case, but it is not fundamental; it is derived from the fundamental equation $V = FTg/W$ after dividing both sides of the equation by T. The notion of instantaneous rate of change of velocity, *i. e.*, acceleration, is not introduced until we give the name acceleration to the quantity dv/dt (or V/T if the acceleration is constant), and the term mass does not appear until we give the name mass to the quotient W/g and thus derive $A = F/M$, or $F = MA$, a most useful equation when we define M as W/g, but it is derived and not fundamental.

Professor Fulcher, April 30:

Gravitational force overcome—weight raised.
Elastic force overcome—spring stretched.
Frictional force overcome—sled dragged.
A pound weight (lb. wt.) is the force required to lift 3.55 cu. in. of iron.

I approve of Professor Fulcher's method of progressing from matters of every-day experience, and it is the method I use, as shown in my article in SCIENCE, December 24, 1909. I am glad to see that he uses the words "weight raised" instead of "mass raised," for the words are in harmony with the young student's understanding of the word weight. I should prefer, however, to say elastic resistance and frictional resistance, instead of elastic force and frictional force. The use of "pound weight (lb. wt.)" instead of the term "pound force" I consider objectionable. The word weight is now used correctly and generally in common language with two meanings, (1) quantity of matter (determined by weighing it on an even balance or by multiplying its volume by its specific gravity), and (2) the force with which the earth's gravity attracts that matter; while the words "pound weight" have a specific meaning, viz., a piece of metal marked 1 lb., used in weighing. Neither "weight" nor "pound weight" are properly applied to the horizontal force required to drag a sled or to a vertical force of 1 lb., as measured on a spring balance, exerted (vainly) to lift a 2 lb. weight.

Before we can determine the effect of a constant unbalanced force in changing the motion of a body, we must study some simple types of motion: (1) uniform; (2) constantly changing speed; (3) parabolic motion; (4) uniform circular motion; (5) motion due to a constant gravitational force.

I would teach (1) very briefly and postpone (2), (3) and (4) until after (5) had been studied experimentally with Atwood's machine, and until after the problem of a heavy boat in still water, pulled with a very small force, say 1 lb. on a 1,000-lb. boat for 4 seconds (frictional resistance neglected) had been studied, deriving the general equation of constant acceleration (2) from the experimental data.

Gravitational Units.—I would drop this term and substitute two others, (1) English units: pound, foot, second, (2) metric units, kilogram (or gram) meter (or centimeter), second. These units are absolute if W is defined as quantity of matter obtained by weighing on an even balance scale and g is 32.1740 ft. per sec. = 980.665 cm. per sec.

Absolute Units.—I would drop this term, also the poundal, and substitute C.G.S. (centimeter-gram-second).

Alexander McAdie, April 30:

Now what is the difficulty with the C.G.S. system?

The difficulty pedagogically is the definition of the dyne, the force that gives a gram of matter an acceleration of 1 centimeter per second per second, and the fact that it has to be translated into its equivalent in ordinary language, a force of 1/980.665 gram, before a clear concept of it can be obtained. If it had been defined as the force which gravity exerts on a gram of matter at 45 deg. latitude at the sea-level, it would have been better. Practically the difficulty is that C.G.S. units derived from the dyne are generally so small that they usually have to be multiplied by a million or more to make them usable, or to express them in such terms as "the joule is 10^7 ergs," and "the ohm is equal to 1,000,000,000 or 10^9 units of resistance of the C.G.S. system."

It is not so difficult for one to break away from the old units as may be imagined. A year's constant use of the C.G.S. units makes one feel like saying when reading of inch measurements "Inch, inch? Where have we met that term before?"

Of course it is not difficult for *one* who is engaged constantly in the use of the C.G.S. system, and who during that year has had no occasion to use the old units, to break away from them, but it is not only difficult but impossible, for a hundred million people who are constantly using the old units to break away from them.

T. L. Porter and R. C. Gowdy, June 4:

We think Professor Kent has done well to retain force and quantity of matter as equally fundamental.

Thanks! I am glad of their company so far, but I can not follow them in adopting the "gravital" as a unit of acceleration. I invented that term myself years ago, as a distance of 32.2 feet, only for the purpose of using it as a "horrible example." I fear now that some one else will adopt my "timal," 1/32.2 of a second. Still less can I accept their micro-speedal or their six Greek letter constants. Perhaps my sense of humor is lacking, in failing to recognize that their article is a joke and a satire, but it reads as if they seriously mean all they say. Here are some brief quotations from their article.

Let $W =$ matter in pounds.
$F =$ force in pounds.

Mass shall be an exact equivalent for quantity of matter.

Weight means the gravitational *force* upon a mass.

The measure of a force may be defined by the equation $F = ma$.

There are 32.2 of the units of force defined by $F = ma$ in a pound weight.

What is the *unit* of m if not the slug?

We frankly talk about a unit of force called the poundal.

If I understand this rightly Messrs. Porter and Gowdy measure matter in both pounds and in slugs, and force in both pounds and in poundals, and to my mind this only increases the existing confusion.

I have just looked over the solution of my problem and I find that it contains twelve technical terms, including one constant, viz., force, pounds, matter, seconds, velocity, distance, acceleration, impulse, momentum, energy, work; $g = 32.1740$.

Messrs. Porter and Gowdy's article contains the same twelve, and also fourteen additional ones, viz., micro-speedals, gravitals, mass, weight, poundals, slugs, pounds-weight, unit and six Greek letter constants. The object of my work has been to eliminate as many useless terms as possible, with the view of making the subject of dynamics easier. Their object seems to be to use as many terms as possible. I wish they would give my problem to a class of their students, and ask them to take it home and bring in written solutions in the method in which they have been taught. The problem for this purpose might have added to it one to be solved arithmetically, such as a 1,000-lb. boat is pulled with a force of 1 lb. for 4 seconds. Assuming that frictional resistance may be neglected, find the distance, velocity, acceleration, etc.

Paul F. Gaehr, June 25:

I say that we may take as our unit of force that force which gives to unit mass a unit acceleration. Let us fetch that backward baby, the poundal, into the room for an inspection at least long enough to learn that the weight of a pound is 32 poundals.

Yes, we may inspect that backward baby a

while, but the students will forget it, just as the students do who are told that we may take as our unit of mass that mass to which unit force (1 pound) gives unit acceleration, and are asked to inspect that more modern baby the slug, alias gee-pound, which will also be forgotten.

Why not teach that the unit of force is that force (1 pound) which gives to unit quantity (1 pound) of matter (call it weight or mass as you will) an acceleration of 32.1740 feet per second, or the force with which a pound of matter is attracted to the earth at a standard locality? That baby was pretty old before the poundal and the slug were born, and now as a strong man is about to attend their funeral.

Professor Huntington, July 30:

(P. 158) Professor Hoskins's method presupposes as a matter of common knowledge the difficult concept of mass or inertia, while my method postpones the introduction of this concept until the student is in a position to define it in terms of the simple concepts of force and acceleration.

(P. 159) Mass as a factor in the determination of motion means the constant ratio of force to acceleration, and whatever the words quantity of matter convey to a beginner's mind they certainly can not convey this desired idea of mass and inertia until *after* the ideas of force and acceleration and the idea of constancy of their ratio for a given body has been accepted.

If $FT = MV$, then $FT/V = F/A$; $F = MV/T = MA$; $T = MV/F =$ Momentum/Force; $V = FT/M =$ Impulse/Mass. Mass no more means the ratio of force to acceleration than force means the time-rate of the increase of momentum, or that time means the ratio of momentum to force, or that velocity means the ratio of impulse to mass. These equations are merely algebraic statements of numerical equality. Not one of them is a definition. Moreover, they are not true, if mass and force are both measured in pounds or in kilograms. They are true in the C.G.S. system, in which force is measured in dynes and mass in grams, and also in the hybrid systems in which force is in poundals and mass in pounds, or force in pounds and mass in slugs. They are also true if it is understood that M is just a symbol for $W \div 32.1740$, W being weight, the word weight being defined as both the force which gravity exerts on a body where $g = 32.1740$ and the quantity of matter in pounds as determined by weighing it on an even balance scale.

There is no difficulty whatever in the beginner's mind in the "concept" of weight with this double definition; his difficulty begins when he is told by the text-books and the teachers that weight is a variable quantity changing with locality, and that mass according to some writers means quantity of matter in slugs, by others it means ratio of force to acceleration, by others that it means the constant ratio of a variable weight (force of gravity) on a body to a variable value of g, and by still others that it is the same thing as inertia.

(P. 164) The awkward attempt to make mass the fundamental unit and force the derived unit has been practically abandoned in the accepted terminology of pure science. Why should it not be abandoned in elementary teaching?

Certainly it should be abandoned, and so also should be abandoned the equally awkward attempt to make mass a derived unit, the ratio of force to acceleration. As Professor Hoskins says in his footnote (page 610, April 23):

Professor Huntington's statement that the mass concept is a "derived concept both historically and practically" is hardly true in any sense in which it is not also true of force. At all events, mass in the sense of quantity of matter has been treated as fundamental by many high authorities from Newton down.

Everybody (writers of text-books on mechanics and some teachers not excepted until they get into "pure science" and become metaphysical) knows that neither force nor quantity of matter are derived concepts; both are elementary and fundamental concepts. As I said six years ago in my article on "The Teaching of Elementary Dynamics in the High School":[1]

Matter.—A stone is suspended by an elastic cord from a nail driven into a projecting shelf. The stone is a piece of matter. . . . Quantity of matter determined by weighing on an even balance scale. The weight of the stone is W pounds.

[1] SCIENCE, Dec. 24, 1909.

Force.—The cord is stretched when the stone is hung on it. Measure the stretch per foot of length. . . . But the cord may be stretched by pulling it between the two hands horizontally. . . . The pull of the earth upon the stone . . . the pull of the hands, . . . each is called by the name force, F.

Space. Time.—Let the cord be suddenly detached from the stone. The stone falls to the ground. It traverses a certain distance, S feet, in a certain time, T seconds.

Here are four elementary, fundamental and independent concepts. Neither one of them is derived from any function or ratio of the other three.

(P. 161) In regard to the equation $V = FTg/W$, which has been proposed by Mr. Kent, my feeling agrees with that expressed by Professor Hoskins, namely that no equation which covers only the special case of a body starting from rest . . . (can be considered as) a fundamental equation in mechanics. Mr. Kent's paper, however, is not without interest on the pedagogical side.

Not without interest! I have been told by those who have used my method that it is pedagogically admirable. The editor of SCIENCE has sent me a letter from an engineer in California enclosing 15 cents for a copy of SCIENCE containing my article, to be sent to his son in college, saying that in 25 years' experience it was the best presentation of the subject he had seen. I presented it on the blackboard at the Princeton meeting of the Society for the Promotion of Engineering Education, June, 1914, where I challenged the professors present that if they did not like my method they write out a better one. Thus far no one has accepted my challenge. The problem is not one of mechanics; it is one of a method of teaching; it is one of pedagogy and the English language, how to find a form of words to be put into a text-book to explain the fundamental principles of dynamics in a way that will appeal to the young student and get these principles into his head in the easiest way possible. After over a year of "watchful waiting" I have put a condensed summary of the method as given in my article in SCIENCE of March 19, 1915, into the chapter on Mechanics in the ninth edition of my "Mechanical Engineers' Pocket-book," which will be off the press about December 10. The young engineers who use the book will there find an antidote to what they have been taught in the past about poundals, slugs, gee-pounds, engineer's unit of mass, derived "concepts," "force is the time-rate of the increase of momentum," "mass is the ratio of force to acceleration," "the unit of mass is 32.2 pounds, the unit of force is 1/32.2 of a pound," and the like. I even have hopes that the Committee on Teaching of Mechanics, of the Society for the Promotion of Engineering Education, of which committee I am a disturbing member, disturbing the slumbers of the committee about once a year, will in two or three years more get over its negative acceleration or minus inertia and adopt my method in its final report.

Professor Hoskins, August 27:

That "the result of weighing a body on a balance scale" is a proper measure of "amount of material" certainly requires explanation to the beginner.

Not to a boy who understands the English language and has ever seen a grocer's scale used to weigh sugar.

I see no reason why the unit which has been called the slug should be regarded with ridicule or even semi-ridicule. The convenience of the slug is due to two facts (1) that the pound force is customarily employed in a great deal of practical work, and (2) that the dynamical formulas almost universally employed are based on a relation of units such that unit force acting on unit mass causes unit acceleration.

The dynamical formulas universally used by engineers are based on no such relation. They are (1) $FT = MV$, (2) $FS = \frac{1}{2}MV^2$, (3) $V = (FT/W) \times g$, and in each case where M is used it means simply W/g.

In order to make the equation $FT = MV$, in anything but the C.G.S. system, harmonize with the statement that "unit force acting on unit mass causes unit acceleration," we must do violence to the English language and custom and use an artificial expedient not sanctioned in literature outside of the text-books, or in commerce, or in engineering practise.

Thus we may say

$$F \times T = M \times V;$$

poundals $\times$ seconds $=$ pounds $\times$ feet per second; 1 poundal $= 1/32.2$ pound force;
pounds $\times$ seconds $=$ slugs $\times$ feet per second; 1 slug $= 32.2$ pounds;
pounds $\times$ timals $=$ pounds $\times$ feet per second; 1 timal $= 1/32.2$ second;
pounds $\times$ seconds $=$ pounds $\times$ gravitals per second; 1 gravital $= 32.2$ feet.

The timal and gravital are just as ridiculous or semi-ridiculous as the poundal or slug, and no more so. Neither one of them has any reason for existence except the pleasing alliteration, copied from the C.G.S. system, "unit force acting on unit mass causes unit acceleration." I see no reason why we should use this principle when it leads to no useful result, but does lead to the worse than useless ones of wasting the time of the student and confusing his mind. If it is such a good thing, why has it not yet been grafted on the metric system? Why do we not have kilogrammal as a unit of force and kiloslug as a unit of quantity of matter?

Is there any reason why in the English system we should not adhere to the good old principle, Unit force (pound) acting on unit mass (1 pound) gives it an acceleration of 32.1740 feet per second?

Professors Franklin and MacNutt, September 24:

> Let us retain as the fundamental meaning of the word mass the result of weighing on a balance scale. . . . Use a balance on a batch of sugar and you get always and everywhere the same numerical result. . . . We respect the experience of two thousand years in that we base our definition of mass on the use of the balance.

I have no objection to the physicists' using the word mass in this sense, but they should not try to prevent their students from using the word weight in the same sense; and I do object to their telling their students that the unit of force is a poundal, when all the rest of the world says it is a pound.

Professor Wilson, October 15:

> To obtain valuable training in kinetics a knowledge of the differential and integral calculus, including the simpler differential equations, is necessary . . . . We therefore have the fundamental equation of kinetics in the form $d/dt\ (mv) = gf$.

The calculus is not at all necessary when we are dealing with uniformly accelerated motion, and valuable training in kinetics was obtained in the study of the early editions of Weisbach, in which calculus was not used. In fact when the problem involves acceleration not constant, but varying according to some assumed law a graphical or arithmetical solution of it will be more useful training than its solution by the calculus. Let Professor Wilson give to his students the boat problem with frictional resistance added and find what results they get by applying his differential formula to it. The problem is: A boat with its load, the total weighing 1,000 pounds, is towed in still water with a constant force of 1 pound. The frictional resistance is $0.2v^2$ pounds, v being speed in ft. per sec., and the force available for acceleration is $(1 - v^2)$ pounds. What speed will the boat have at the end of 1, 2, 3 and 4 minutes; how far will it travel each minute and how long time will it take to bring it to a speed of 0.999 of the theoretical maximum at which the acceleration is zero?

> It is of course true that weight is not a definite constant thing from place to place.

It is a constant thing if weight is defined, as is customary in commerce, as the quantity of matter in pounds determined by weighing it on an even balance.

> . . . proceed to Newton's law that the rate of change of momentum is equal to the force. Here however we have an equation that is no longer homogeneous either in the mass or in the force.

This is a new kind of language to me. I confess my ignorance of the meaning of the phrase "homogeneous either in the mass or in the force." Whatever it may mean it surely has no place on "elementary" mechanics.

> The equation $ma = f$, or any equation involving accelerations leads to the ridiculously needless concepts of transverse and longitudinal (and an infinity of oblique) masses.

Here again Professor Wilson is too deep for me. I have used the equation $ma = f$ for forty years (understanding that m means the quotient w/g) and never have been led to any such concepts. I thank Professor Wilson for the expression "ridiculously needless con-

cepts." It fits exactly the poundals, slugs, gee-pounds, engineers' unit of mass, gravitals, micro-speedals, kinetic unit, scientific unit, absolute and gravitational systems, "concepts of mass," "force is the space-rate at which work in foot pounds is done, it is also the time rate at which momentum is produced or destroyed" (Perry's "Calculus") and all such pedagogical rubbish.

> Our first object is to get the student into a position where he can solve such simple problems as he sees in actual work about him, and a certain amount of ignorance which would be very lamentable on the part of myself and your other contributors, is highly praiseworthy in the student.

Good! Now will Professor Wilson examine the simple problem I have given and my method of solving it and get one of his instructors to experiment on the method with some freshmen students and report the result? "Try it on the dog." Test it not only by the canons of logic and of common sense, but also by experience.

> Any student knows what a weight of four pounds is.

Of course he does, until he begins the study of physics; then he may be in some doubt about it. He knows that it is a piece of metal with "4 lb." stamped on it, but when he is told that that is not a weight, but mass, and that a weight of four pounds means a force of four pounds, also that a mass is "the constant ratio of force to acceleration," and that "he can not acquire the desired ideas of mass and inertia until after the ideas of force and acceleration have been accepted," it is no wonder that he becomes confused, and replies to the simple question, "What is force?" "The time-rate of the change of momentum," quoting from the text-book, without knowing what the words mean.

Wm. Kent

A MNEMONIC COUPLET FOR GEOLOGIC PERIODS

Several years of experience in teaching geology led me, some time since, to the invention or discovery of the following scheme for helping students to remember the order of geologic periods.

The form offered here is adapted to the plan presented in Chamberlin and Salisbury's "College Geology," which is widely used. It may be modified without serious difficulty to suit other time divisions.

Neglecting the Pre-Cambrian, somewhat as common histories do pre-historic time, and also the recent epoch, we take the periods of the Paleozoic era, Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian and Permian; of the Mesozoic, Triassic, Jurassic, Comanche and Cretaceous; and of the Cenozoic, Eocene (Oligocene), Miocene, Pliocene and Pleistocene.

Taking the first syllable of each period, and adding the termination *ice* to the Permian to commemorate the glacial epoch of that time, and also to rhyme with "Pleis," which also reminds one of the better known epoch of the same sort, we have the following jingle:

Cam.Or.Sil.De.
  Miss.Penn.Perm-*ice*,
Tri.Ju.Co.Cre.
  E.(Ol.).Mi.Pli.Pleis.

Some of the divisions here counted periods may be more fittingly called epochs, but that makes no difference with the order.

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VARIATION IN ŒNOTHERA HEWETTI

Dr. G. H. Shull[1] recently published a paper on "A Peculiar Negative Correlation in *Œnothera* Hybrids," in which he showed that in certain cultures dull dark red stems were associated with entirely green buds, and gave other evidence indicating that the appearance of anthocyan in one part of the plant by no means involved its appearance in other parts.

I have this year a series of plants of *Œnothera hewetti,* descended from the original plant brought from the Rito de los Frijoles, New Mexico, in 1912. This is a relative of *Œ. hookeri,* and quite distinct from the species used by Dr. Shull. Nevertheless, it varies in pigmentation along practically the same lines.

[1] *Journal of Genetics,* IV., 1914, p. 83.